Chapter 4
Phytoplankton and Chlorophyll, 2001-2002

Introduction

The Department of Water Resources (DWR) and the United States Bureau of Reclamation (USBR) collect phytoplankton and chlorophyll *a* samples in order to monitor algal community composition and biomass in the San Francisco Estuary (Estuary) in compliance with D-1641. The eleven sampling sites range from San Pablo Bay east to the mouths of the Sacramento, Mokelumne, and San Joaquin rivers. These sites represent a variety of aquatic habitats, from narrow, freshwater channels in the Delta to broad, estuarine bays. This chapter describes the results of these monitoring efforts for calendar years 2001 and 2002.

Primary production (carbon fixation through photosynthesis) by phytoplankton is one of the key processes that influence water quality in the Estuary. Phytoplankton can affect pH, dissolved oxygen, color, taste and odor, and under certain conditions, some species can develop noxious blooms resulting in animal deaths and human illness (Carmichael 1981). Phytoplankton are small, free-floating organisms that occur as unicellular, colonial or filamentous forms (Horne and Goldman 1994). In addition to their being an important food source for zooplankton, invertebrates, and some species of fish, phytoplankton species assemblages can also be useful in assessing water quality (Gannon and Stemberger 1978). Due to their short life cycles, phytoplankton respond quickly to environmental changes, and hence their standing crop and species composition are indicative of the quality of the water mass in which they are found (APHA 1998). However, because of their transient nature, patchiness and free movement in a lotic environment, the utility of phytoplankton as water quality indicators is limited, and should be interpreted in conjunction with physiochemical and other biological data (APHA 1998).

Chlorophylls are complex phytopigment molecules found in all photosynthetic plants, including phytoplankton. There are several types of chlorophyll identified by slight differences in their molecular structure and constituents. These include chlorophyll *a, b, c,* and *d*. Chlorophyll *a* is the principal photosynthetic pigment and is common to all phytoplankton. Chlorophyll *a* concentration is thus used as a measure of phytoplankton biomass.

In addition to chlorophyll *a*, water samples were analyzed for pheophytin *a*. Pheophytin *a* is a primary degradation product of chlorophyll *a*, and its concentration, relative to chlorophyll *a*, is useful for estimating the general physiological state of phytoplankton populations. When phytoplankton are actively growing, the concentrations of pheophytin *a* are normally expected to be low in relation to chlorophyll *a*. Conversely, high concentrations of pheophytin *a* relative to chlorophyll *a* generally indicate that phytoplankton have ceased growing and are decomposing.

Phytoplankton biomass and resulting chlorophyll *a* concentrations in some areas of the Estuary may be influenced by extensive filtration of the water column by the introduced Asian clam, *Potamocorbula amurensis* (Alpine and Cloern 1992). Well-established benthic populations of *P. amurensis* in Suisun and San Pablo bays are thought to have contributed to the low chlorophyll *a* concentrations (and increased water clarity) measured in these westerly bays since the mid-1980s (Alpine and Cloern 1992).

Methods

Phytoplankton

Phytoplankton samples were collected monthly at 11 monitoring sites throughout the upper Estuary (Figure 4-1). Samples were collected using a Van Dorn water sampler or a submersible pump from 1 meter below the water's surface. The samples were stored in 50-milliliter glass bottles. Lugol's solution was added to each sample as a stain and preservative. All samples were kept at room temperature and away from direct sunlight until they were analyzed.

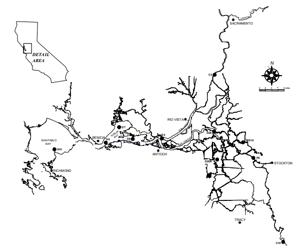

Figure 4-1 Map of chlorophyll and phytoplankton monitoring stations

Phytoplankton identification and enumeration were performed at the DWR's Bryte Laboratory according to the Utermöhl microscopic method (Utermöhl 1958) and modified Standard Methods (APHA 1998). An aliquot was placed into a counting chamber and allowed to settle for a minimum of 15 hours. The aliquot volume, normally 10 mL, was adjusted according to the algal population density and turbidity of the sample. Phytoplankton were enumerated in twenty randomly chosen fields of a Whipple ocular micrometer grid for each settled aliquot. Sample analysis was conducted at a magnification of 700X using a Wilde M-40 inverted microscope.

Organism counts for each sample can be converted to organisms/ml using the following formula:

$$\textbf{Organisms} = (C \times Ac) / (V \times Af \times F)$$

Where:

Organisms	=	Number of organisms (#/ml)
C	=	Count obtained
Ac	=	Area of cell bottom (mm^2)
Af	=	Area of each grid field (mm^2)
F	=	Number of fields examined (#)
V	=	Volume settled (mL)

This simplifies to:

$$\textbf{Organisms} = C / cV$$

Where:

cV	=	Counted volume (mL)

(Note: cV = Ac /(V x Af x F))

Chlorophyll *a*

Chlorophyll *a* samples were collected monthly at 11 monitoring sites throughout the upper Estuary (Figure 4-1) using a Van Dorn water sampler or a submersible pump from 1 meter below the water's surface. Approximately 500 mL of water was passed through a 47 mm diameter glass fiber filter with a 1.0 µm pore size at a pressure of 10 inches of mercury. The filters were immediately frozen and transported to Bryte Laboratory for analysis according to Standard Methods (APHA 1998) spectrophotometric procedure. Samples were processed by mechanically grinding the glass fiber filters and extracting the phytopigments with acetone. Chlorophyll *a* and pheophytin *a* pigment absorptions were measured with a spectrophotometer before and after acidification of the sample. Concentrations were calculated according to Standard Method's formula (APHA 1992). In addition, percent chlorophyll *a* was calculated as the ratio of chlorophyll *a* concentration to chlorophyll *a* plus pheophytin *a* concentrations multiplied by 100.

Results

Phytoplankton Identification

Of the eight families identified, Bacillariophyceae, Chlorophyceae, and unidentified flagellates constituted 94.1% of the organisms collected during 2001 and 2002. Figure 4-2 shows the total phytoplankton contribution by family for all sites. Table 4-1 lists the genera found in each family in the upper Estuary.

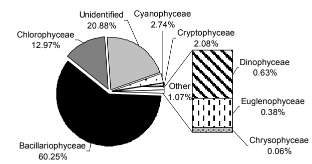

Figure 4-2 Total phytoplankton contribution by family at all stations

All organisms collected during the 2001 and 2002 fell into these eight families:

- Bacillariophyceae (Diatoms)
- Chlorophyceae (Green algae)
- Chrysophyceae (Yellow-brown algae)
- Cryptophyceae (Cryptomonads)
- Cyanophceae (Blue-green algae)
- Dinophyceae (Dinoflagellates)
- Euglenophyceae (Euglenoids)
- Unidentified flagellates (Flagellates)

Family	Genus	Family	Genus
Bacillariophyceae	Achnanthes	Chlorophyceae	Actinastrum
	Amphiprora		Ankistrodesmus
	Amphora		Carteria
	Asterionella		Chlamydomonas
	Bacillaria		Chlorella
	Ceratoneis		Closteriopsis
	Cocconeis		Closterium
	Cosinodiscus		Coelastrum
	Cyclotella		Crucigenia
	Cymbella		Desmidium
	Diatoma		Dictyosphaerium
	Fragilaria		Dimorphococcus
	Gomphonema		Elakatothrix
	Gyrosigma		Eudorina
	Melosira		Micractinium
	Navicula		Oocystis
	Neidium		Pandorina
			Pediastrum
Chrysophyceae	Synura		Pyramimonas
			Scenedesmus
Cryptophyceae	Cryptomonas		Schroederia
	Rhodomonas		Selenastrum
			Sphaerocystis
Cyanophyceae	Agmenellum		Staurastrum
	Anabaena		Tetraedron
	Anabaenopsis		Tetrastrum
	Anacystis		Ulothrix
	Aphanizomenon		Xanthidium
	Gomphosphaeria		
	Oscillatoria		
	Spirulina		
Dinophyceae	Ceratium		
	Glenodinium		
	Gymnodinium		
	Peridinium		
Euglenophyceae	Euglena		
	Trachelomonas		
Unidentified	Unidentified Flagellates		

Table 4-1 All genera found in each family in the upper San Francisco Estuary

A list of all phytoplankton genera identified, their shape codes, and the total number counted can be found in the *Phytoplankton Dictionary* available online at http://www.iep.ca.gov/emp/Metadata/phytoplankton_metadata.html.

Pigment Concentrations

Chlorophyll *a* concentrations showed seasonal patterns. The highest chlorophyll *a* concentrations occurred during the spring for most stations, with a second increase usually occurring during the late summer or early fall. Pheophytin *a* concentrations remained fairly constant and did not show apparent seasonal patterns.

With the exception of high values seen at three stations in the south and east Delta (C10, P8, and MD10) chlorophyll *a* and pheophytin *a* concentrations were generally in the range of 0.5 µg/L and 15 µg/L throughout the upper Estuary. The highest concentrations of chlorophyll *a* occurred at Vernalis (station C10) on the San Joaquin River during July 2001 (109.4 µg/L) and July 2002 (79.45 µg/L), at Disappointment Slough (station MD10) on the Mokelumne River during April 2001 (62.8 µg/L) and April 2002 (49.6 µg/L), and at Buckley Cove (station P8) on the San Joaquin River during October 2001 (22.9 µg/L) and September 2002 (21.2 µg/L). These stations are located in the southern and eastern regions of the Sacramento-San Joaquin Delta.

From east to west, the concentration of chlorophyll *a* showed a decreasing trend, with the exception of station C3 (Sacramento River at Hood). Figures 4-3 through 4-13 show the results of chlorophyll *a* and pheophytin *a* analysis. All chlorophyll *a* and pheophytin *a* data can be found at http://www.iep.ca.gov/emp/Data_access.html.

Site C3: North Delta

The maximum chlorophyll *a* concentration during 2001 occurred in May (5.70 µg/L) (Figure 4-3). The minimum concentration during 2001 occurred in November (1.52 µg/L). The maximum chlorophyll *a* concentration during 2002 occurred in June (5.07 µg/L). The minimum chlorophyll *a* concentration during 2002 occurred in November (1.45 µg/L). Diatoms (Bacillariophyceae) were primarily responsible for the observed peaks in chlorophyll *a*.

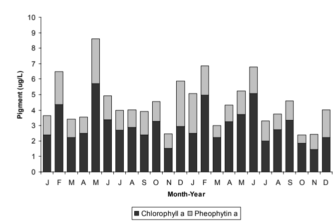

Figure 4-3 Chlorophyll *a* and pheophytin *a* concentrations at station C3, 2001–2002

The maximum pheophytin *a* concentration during 2001 occurred in December (2.96 µg/L). No phytoplankton were found in the December 2001 sample. The minimum concentration occurred in November 2001 (0.95 µg/L). The maximum pheophytin *a* concentration during 2002 occurred in January (2.59 µg/L). The minimum pheophytin *a* concentration occurred in March (0.77 µg/L). Diatoms (Bacillariophyceae) were primarily responsible for the observed peaks in pheophytin *a*.

Station C3 demonstrated a clear seasonal pattern with the highest chlorophyll *a* concentrations recorded during the spring and the lowest recorded during the fall.

Site MD10: East Delta

The maximum chlorophyll *a* concentration during 2001 occurred in April (62.8 µg/L) (Figure 4-4). The minimum concentration during 2001 occurred in December (1.53 µg/L). The maximum chlorophyll *a* concentration during 2002 occurred in April (49.6 µg/L). The minimum concentration during 2002 occurred in January (0.68 µg/L). Diatoms (Bacillariophyceae) were primarily responsible for the observed peaks in chlorophyll *a*.

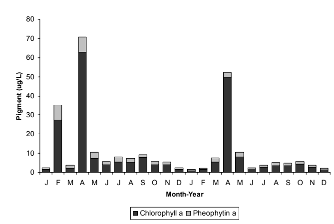

Figure 4-4 Chlorophyll *a* and pheophytin *a* concentrations at station MD10, 2001–2002

In 2001, the maximum pheophytin *a* concentration occurred in April (7.95 µg/L) and was associated with diatoms (Bacillariophyceae). The minimum concentration occurred in January 2001 (0.83 µg/L). The maximum pheophytin *a* concentration during 2002 occurred in April

(2.69 µg/L) and was also associated with diatoms (Bacillariophyceae). The minimum concentration of pheophytin *a* occurred in December 2002 (0.65 µg/L).

Station MD10 demonstrated a clear seasonal pattern with the highest concentrations recorded during the spring and the lowest recorded during the winter.

Site C10: South Delta

The maximum chlorophyll *a* concentration during 2001 occurred in July (109.4 µg/L) (Figure 4-5). The minimum concentration during 2001 occurred in December (3.83 µg/L). The maximum chlorophyll *a* concentration during 2002 occurred in August (118.0 µg/L). The minimum concentration during 2002 occurred in January (5.1 µg/L). Diatoms (Bacillariophyceae) were primarily responsible for the observed peaks in chlorophyll *a*.

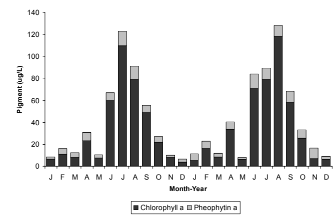

Figure 4-5 Chlorophyll *a* and pheophytin *a* concentrations at station C10, 2001–2002

The maximum pheophytin *a* concentration during 2001 occurred in July (13.66 µg/L). The minimum concentration occurred in November (2.13 µg/L). The maximum pheophytin *a* concentration during 2002 occurred in June (12.85 µg/L). The minimum pheophytin *a* concentration occurred in May (2.03 µg/L). Diatoms (Bacillariophyceae) were primarily responsible for the observed peaks in pheophytin *a*.

Station C10 demonstrated a clear seasonal pattern with the highest pigment concentrations recorded during the summer and early fall, and the lowest recorded during the winter.

Site P8: South Delta

The maximum chlorophyll *a* concentration during 2001 occurred in October (22.95 µg/L) (Figure 4-6). The minimum concentration during 2001 occurred in June (3.01 µg/L). The maximum chlorophyll *a* concentration during 2002 occurred in September (21.15 µg/L). The minimum concentration during 2002 occurred in January (3.36 µg/L). Diatoms (Bacillariophyceae) and green algae (Chlorophyceae) were primarily responsible for the observed peaks in chlorophyll *a*.

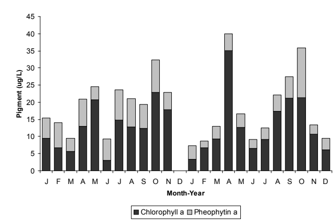

Figure 4-6 Chlorophyll *a* and pheophytin *a* concentrations at station P8, 2001–2002

The maximum pheophytin *a* concentration during 2001 occurred in October (9.45 µg/L). This peak was associated with unidentified flagellates and green algae (Chlorophyceae). The minimum concentration occurred in May (3.81 µg/L). The maximum pheophytin *a* concentration during 2002 occurred in October (14.4 µg/L). The phytoplankton family associated with this peak was unidentified flagellates. The minimum concentration occurred in February 2002 (1.96 µg/L).

Station P8 demonstrated a clear seasonal pattern with the highest concentrations recorded during the spring and an additional peak during the fall. The lowest recorded concentrations occur during the winter and summer.

Site D28A: Central Delta

The maximum chlorophyll *a* concentration during 2001 occurred in May (5.83 µg/L) (Figure 4-7). Diatoms (Bacillariophyceae) were primarily responsible for this peak. The minimum concentration during 2001 occurred in December (1.27 µg/L). The maximum chlorophyll *a* concentration at D28A during 2002 occurred in April (5.81 µg/L). The minimum concentration during 2002 occurred in January (0.55 µg/L). Unidentified flagellates were primarily responsible for this observed peak.

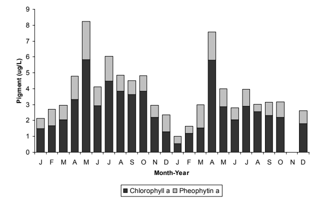

Figure 4-7 Chlorophyll *a* and pheophytin *a* concentrations at station D28A, 2001–2002

The maximum pheophytin *a* concentration during 2001 occurred in April (2.40 µg/L). Diatoms (Bacillariophyceae) and unidentified flagellates were primarily responsible for this peak. The minimum concentration occurred in January (0.67 µg/L). The maximum pheophytin *a* concentration during 2002 occurred in April (1.76 µg/L). Unidentified flagellates were primarily responsible for this peak. The minimum concentration occurred in August (0.46 µg/L).

Station D28A demonstrated a clear seasonal pattern with the highest concentrations recorded during the spring and summer and the lowest recorded are during the winter.

Site D26: Lower San Joaquin River

The maximum chlorophyll *a* concentration during 2001 occurred in May (6.52 µg/L) (Figure 4-8). The minimum concentration during 2001 occurred in February (0.71 µg/L). The maximum chlorophyll *a* concentration during 2002 occurred in June (9.63 µg/L). Minimum concentration during 2002 occurred in January (0.88 µg/L). Diatoms (Bacillariophyceae) were primarily responsible for the observed peaks in chlorophyll *a*.

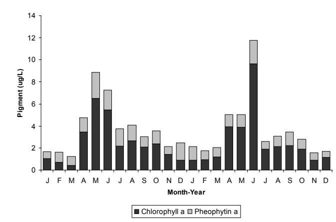

Figure 4-8 Chlorophyll *a* and pheophytin *a* concentrations at station D26, 2001–2002

The maximum pheophytin *a* concentration during 2001 occurred in May (2.36 µg/L). The minimum concentration occurred in January (0.61 µg/L). The maximum pheophytin *a* concentration during 2002 occurred in June (1.16 µg/L). The minimum concentration occurred in December (0.56 µg/L). Diatoms (Bacillariophyceae) were primarily responsible for the observed peaks in chlorophyll *a*.

Station D26 demonstrated a clear seasonal pattern with the highest concentrations recorded during the spring and summer and the lowest recorded were during the winter months.

Site D4: Lower Sacramento River

The maximum chlorophyll *a* concentration during 2001 occurred in May (5.76 µg/L) (Figure 4-9). Diatoms (Bacillariophyceae) were primarily responsible for this peak. The minimum concentration during 2001 occurred in January (0.92 µg/L). The maximum chlorophyll *a* concentration during 2002 occurred in May (9.44 µg/L). Green algae (Chlorophyceae) and diatoms (Bacillariophyceae) were primarily responsible for this observed peak. The minimum concentration during 2002 occurred in September (0.99 µg/L).

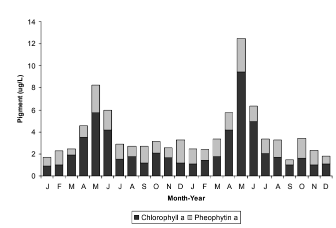

Figure 4-9 Chlorophyll *a* and pheophytin *a* concentrations at station D4, 2001–2002

The maximum pheophytin *a* concentration during 2001 occurred in May (2.48 µg/L). The phytoplankton family associated with this peak was diatoms (Bacillariophyceae). The minimum concentration occurred in March (0.58 µg/L). The maximum pheophytin *a* concentration during 2002 occurred in May (3.04 µg/L). The minimum concentration occurred in September (0.47 µg/L). Diatoms (Bacillariophyceae) were primarily responsible for the observed peaks in pheophytin *a*.

Station D4 demonstrated a clear seasonal pattern with the highest concentrations recorded during the spring and summer and the lowest during the fall and winter.

Site D8: Suisun Bay

The maximum chlorophyll *a* concentration during 2001 occurred in June (3.63 µg/L) (Figure 4-10). Diatoms (Bacillariophyceae) were primarily responsible for this observed peak. The minimum concentration during 2001 occurred in December (0.90 µg/L). The maximum chlorophyll *a* concentration during 2002 occurred in May (3.75 µg/L). Cryptomonads (Cryptophyceae) were primarily responsible for this observed peak. The minimum concentration during 2002 occurred in January (1.07 µg/L).

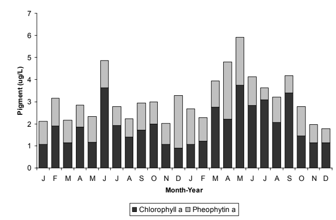

Figure 4-10 Chlorophyll *a* and pheophytin *a* concentrations at station D8, 2001–2002

The maximum pheophytin *a* concentration during 2001 occurred in December (2.37 µg/L). No phytoplankton were collected at this station in December 2001. The minimum concentration occurred in August (0.83 µg/L). The maximum pheophytin *a* concentration during 2002 occurred in April (2.59 µg/L). Unidentified flagellates were primarily responsible for this observed peak. The minimum concentration occurred in July (0.54 µg/L).

Chlorophyll *a* and pheophytin *a* levels remained low and stable (range 0.54 to 3.75 µg/L) for both years. A peak of 3.63 µg/L occurred in June in 2001. A seasonal pattern was demonstrated in 2002 with the highest concentrations during the spring and the lowest during the winter.

Site D7: Suisun Bay

The maximum chlorophyll *a* concentration during 2001 occurred in July (2.35 µg/L) (Figure 4-11). Diatoms (Bacillariophyceae) were primarily responsible for this observed peak. The minimum concentration during 2001 occurred in June (1.02 µg/L). The maximum chlorophyll *a* concentration during 2002 occurred in March (11.70 µg/L). Unidentifiable flagellates were primarily responsible for this observed peak. The minimum concentration during 2002 occurred in November (0.84 µg/L).

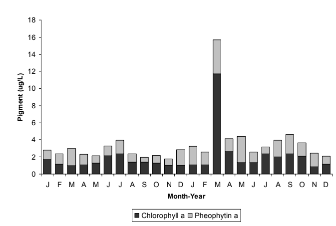

Figure 4-11 Chlorophyll *a* and pheophytin *a* concentrations at station D7, 2001–2002

The maximum pheophytin *a* concentration during 2001 occurred in March with 2.02 µg/L. No phytoplankton were identified in the March 2001 sample. The minimum concentration occurred in November (0.73 µg/L). The maximum pheophytin *a* concentration during 2002 occurred in March (3.96 µg/L). Unidentified flagellates were primarily responsible for this observed peak. The minimum concentration occurred in July (0.81 µg/L).

The chlorophyll *a* and pheophytin *a* concentrations were stable (concentrations below 2.35 µg/L) at this station with the exception of one peak in May 2002.

Site D6: Suisun Bay

The maximum chlorophyll *a* concentration during 2001 occurred in May (3.01 µg/L) (Figure 4-12). The minimum concentration during 2001 occurred in November (0.69 µg/L). The maximum chlorophyll *a* concentration during 2002 occurred in March (3.51 µg/L). The minimum concentration during 2002 occurred in January (0.77 µg/L). Diatoms (Bacillariophyceae) were primarily responsible for the observed peaks in chlorophyll *a*.

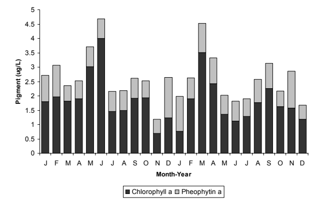

Figure 4-12 Chlorophyll *a* and pheophytin *a* concentrations at station D6, 2001–2002

The maximum pheophytin *a* concentration during 2001 occurred in December (1.41 µg/L). Diatoms (Bacillariophyceae) and unidentified flagellates were primarily responsible for this observed peak. The minimum concentration occurred in November (0.50 µg/L). The maximum pheophytin *a* concentration during 2002 occurred in November (1.28 µg/L). Unidentified flagellates were primarily responsible for this observed peak. The minimum concentration occurred in December (0.49 µg/L).

Station D6 demonstrated a clear seasonal pattern with the highest concentrations recorded during the spring.

Site D41: San Pablo Bay

The maximum chlorophyll *a* concentration during 2001 occurred in May (6.66 µg/L) (Figure 4-13). Unidentified flagellates were primarily responsible for this observed peak. The minimum concentration during 2001 occurred in December (1.43 µg/L). The maximum chlorophyll *a* concentration during 2002 occurred in May (4.78 µg/L). Diatoms (Bacillariophyceae) were primarily responsible for this observed peak. The minimum concentration during 2002 occurred in December (2.0 µg/L).

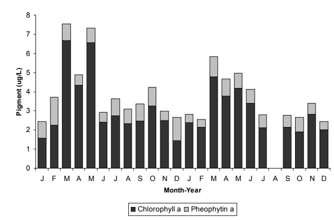

Figure 4-13 Chlorophyll *a* and pheophytin *a* concentrations at station D41, 2001-2002

The maximum pheophytin *a* concentration during 2001 occurred in February (1.45 µg/L). Diatoms (Bacillariophyceae) were primarily responsible for this observed peak. The minimum concentration occurred in November (0.50 µg/L). The maximum pheophytin *a* concentration during 2002 occurred in May (1.05 µg/L). Unidentifiable flagellates were primarily responsible for this observed peak. The minimum concentration occurred in February (0.41 µg/L).

Station D41 demonstrated a clear seasonal pattern with the highest chlorophyll *a* concentrations recorded during the spring and the lowest occurring during the winter.

Summary

DWR and USBR collect phytoplankton samples in order to monitor algal community composition and biomass in the San Francisco Estuary. In 2001 and 2002 all phytoplankton species collected fell into the families: Bacillariophyceae (Diatoms), Chlorophyceae (Green algae), Chrysophyceae (Yellow-brown algae), Cryptophyceae (Cryptomonads), Cyanophyceae

(Blue-green algae), Dinophyceae (Dinoflagellates), Euglenophyceae (Euglenoids), and unidentified flagellates (Flagellates). Of the eight families identified; the Bacillariophyceae, Chlorophyceae, and unidentified flagellates constituted 94.1% of the organisms collected.

Chlorophyll *a* concentrations showed seasonal patterns. The highest chlorophyll *a* concentrations occurred during the spring for most stations, with a second increase most often occurring during the late summer or early fall. From east to west, the concentration of chlorophyll *a* showed a decreasing trend. Chlorophyll *a* and pheophytin *a* concentrations were generally in the range of 0.5 µg/L and 15 µg/L throughout the upper Estuary, with the exception of high values seen at three stations in the south and east Delta.

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Figure 4-1 Map of chlorophyll and phytoplankton monitoring stations

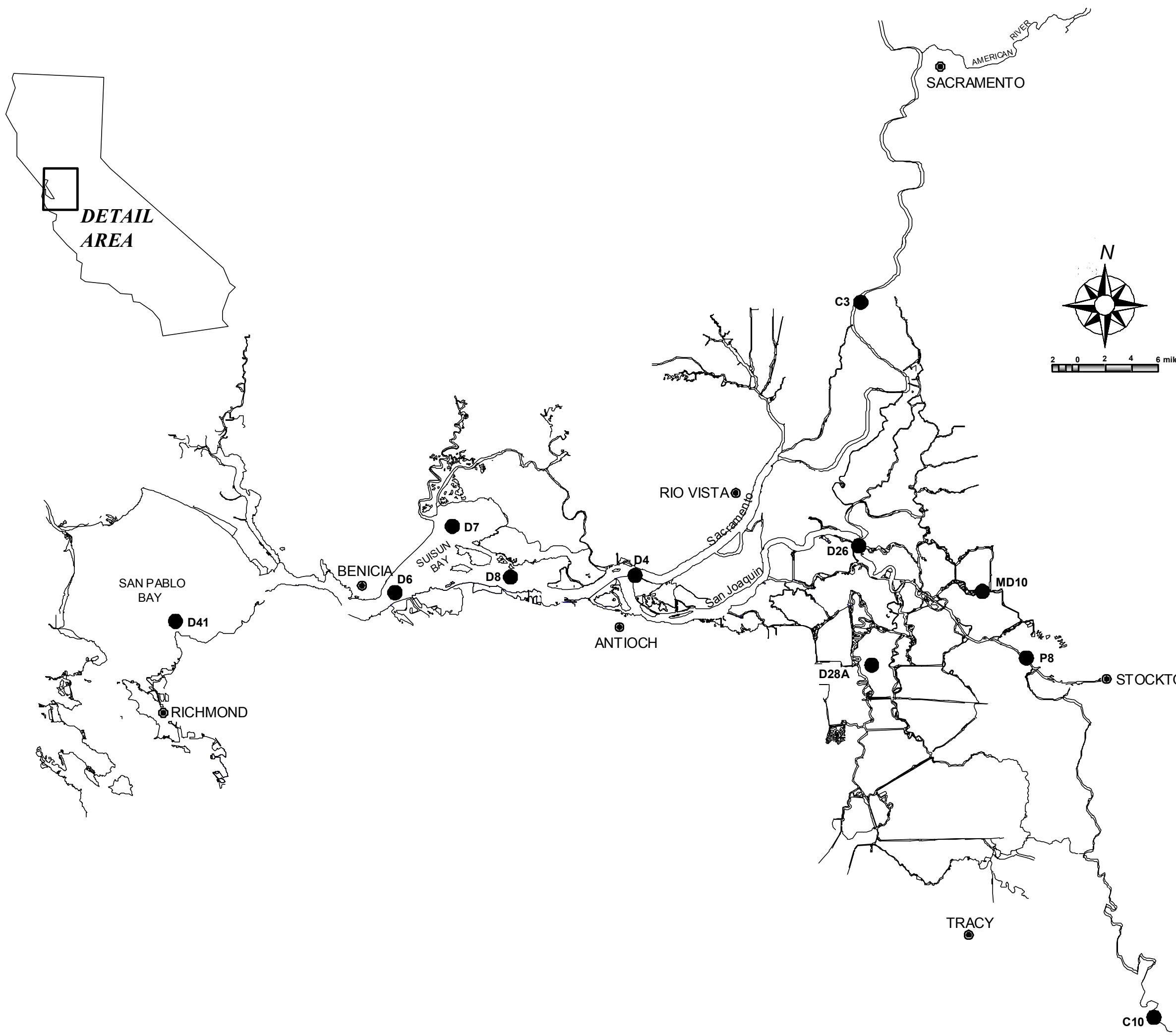

Figure 4-2 Total phytoplankton contribution by family at all stations

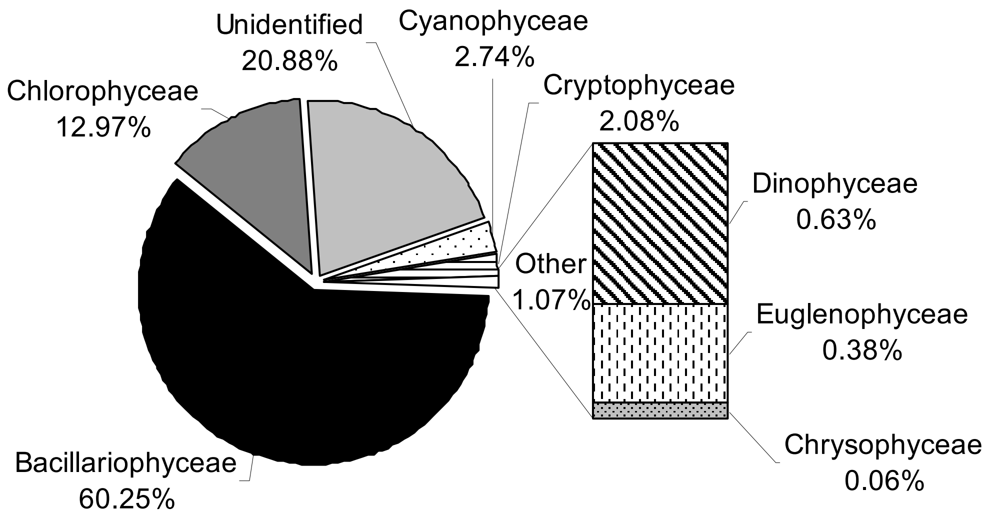

Figure 4-3 Chlorophyll *a* and pheophytin *a* concentrations at station C3, 2001-2002

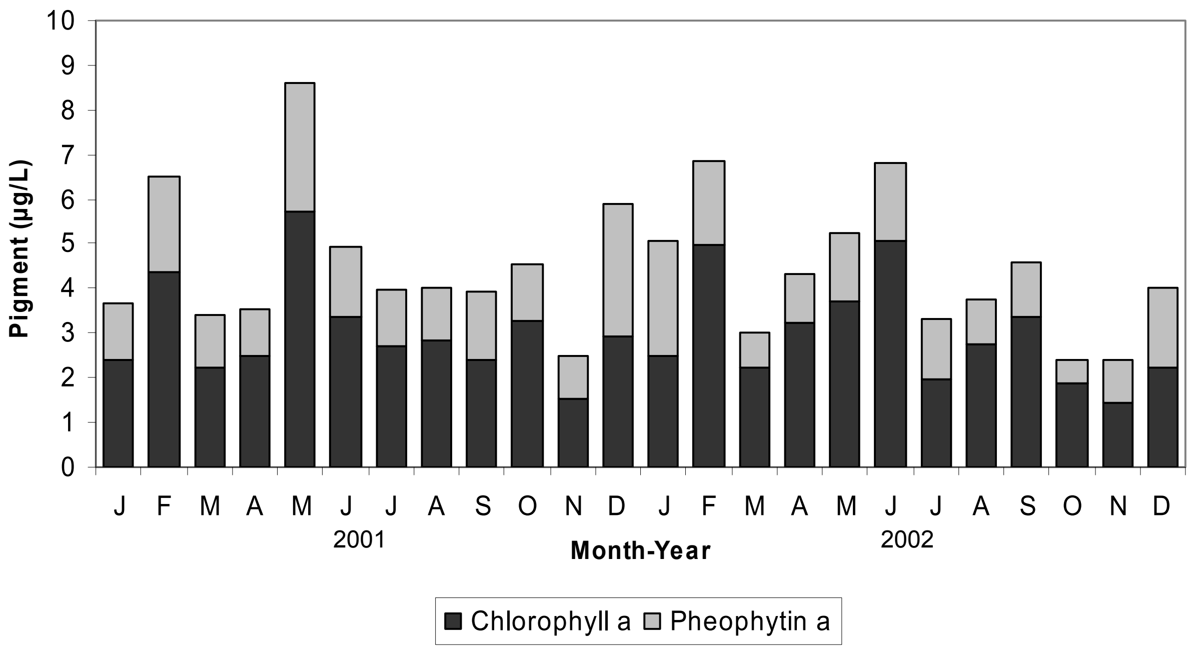

Figure 4-4 Chlorophyll *a* and pheophytin *a* concentrations at station MD10, 2001-2002

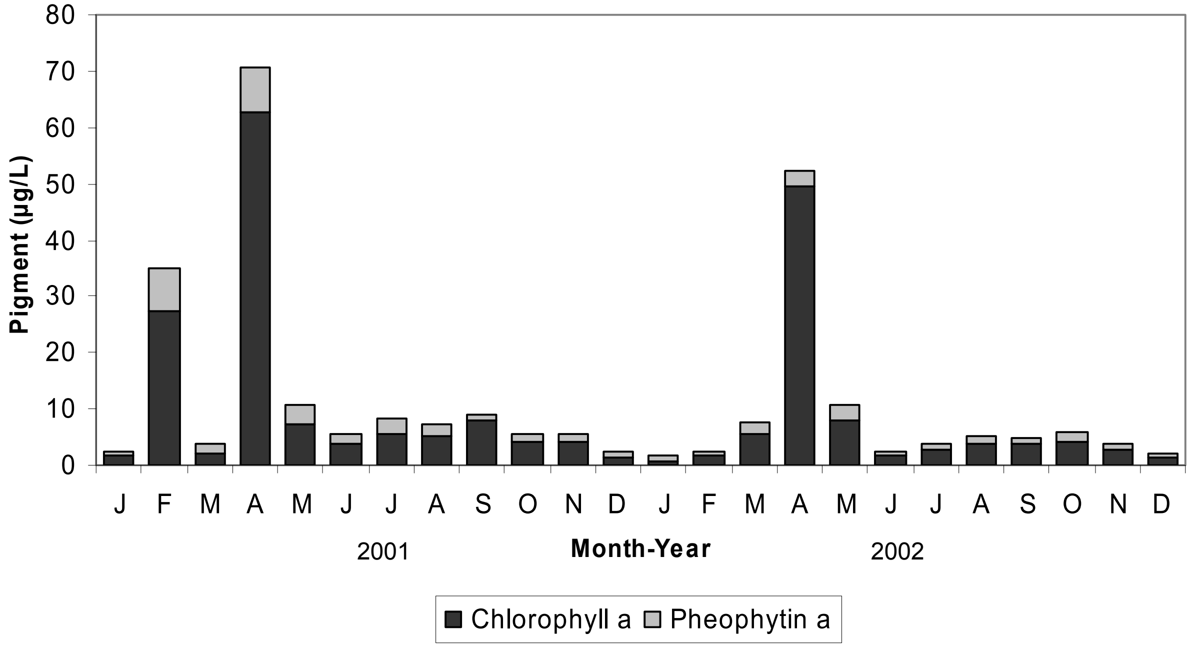

Figure 4-5 Chlorophyll *a* and pheophytin *a* concentrations at station C10, 2001-2002

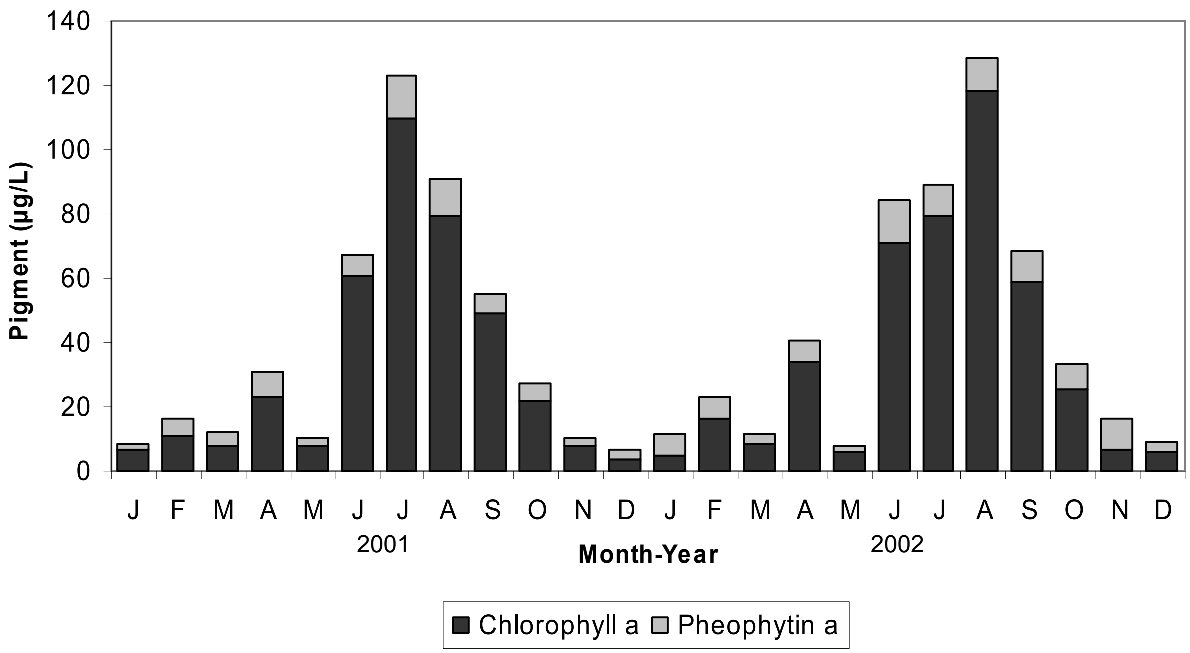

Figure 4-6 Chlorophyll *a* and pheophytin *a* concentrations at station P8, 2001-2002

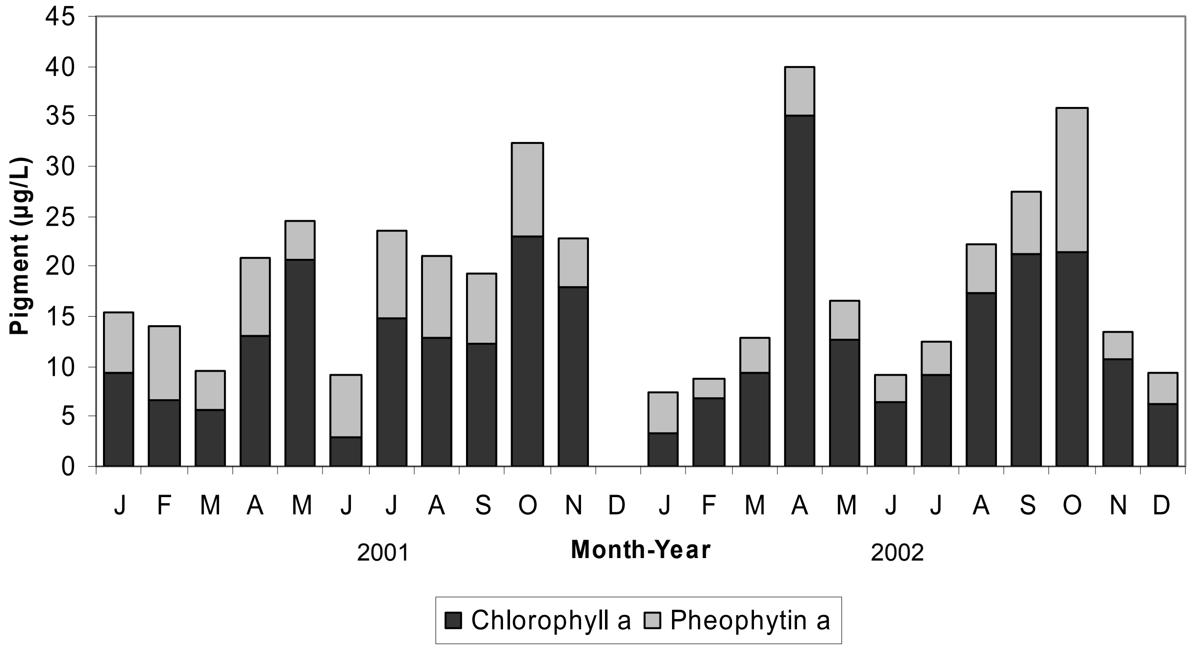

Figure 4-7 Chlorophyll *a* and pheophytin *a* concentrations at station D28A, 2001-2002

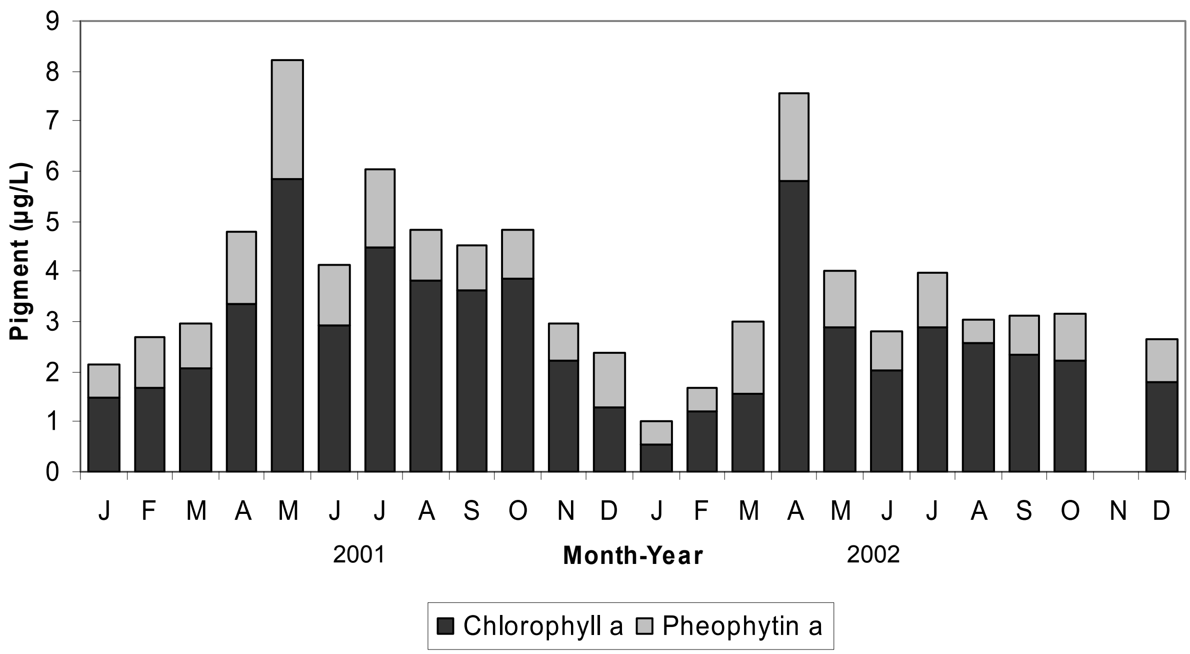

Figure 4-8 Chlorophyll *a* and pheophytin *a* concentrations at station D26, 2001-2002

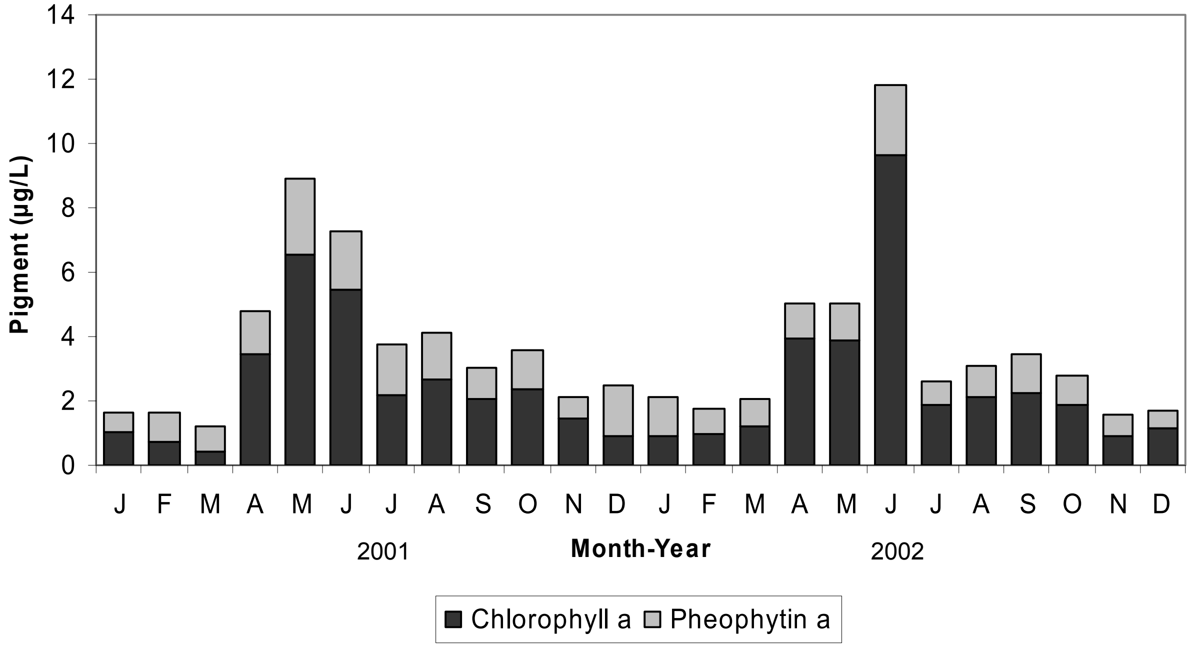

Figure 4-9 Chlorophyll *a* and pheophytin *a* concentrations at station D4, 2001-2002

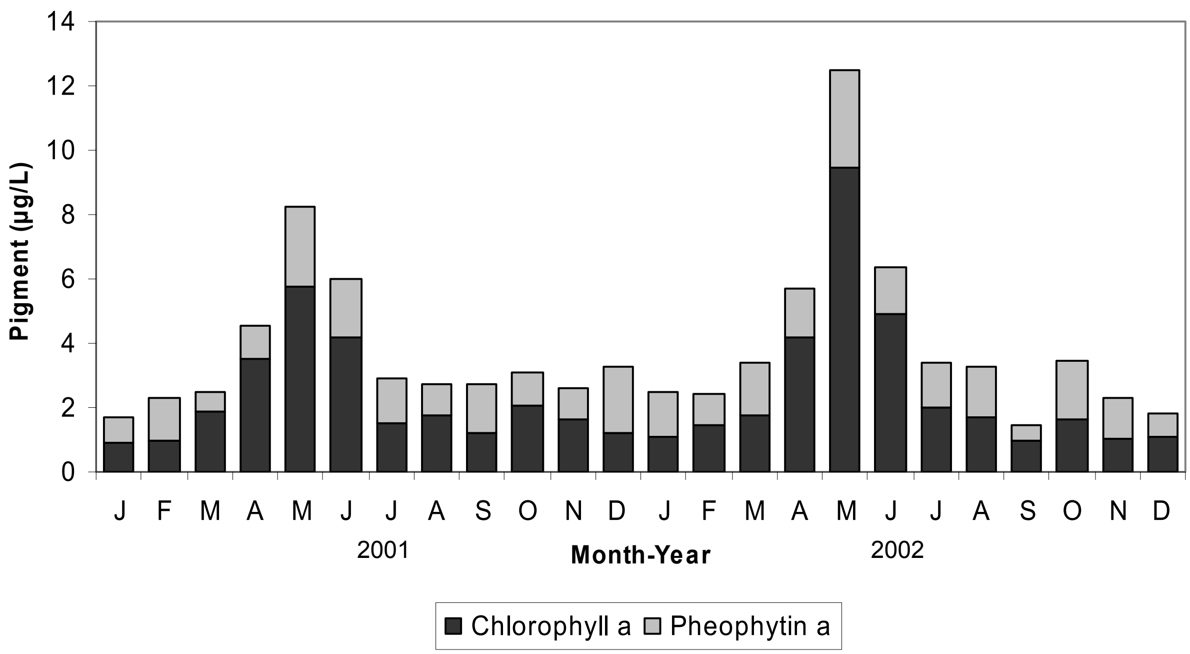

Figure 4-10 Chlorophyll *a* and pheophytin *a* concentrations at station D8, 2001-2002

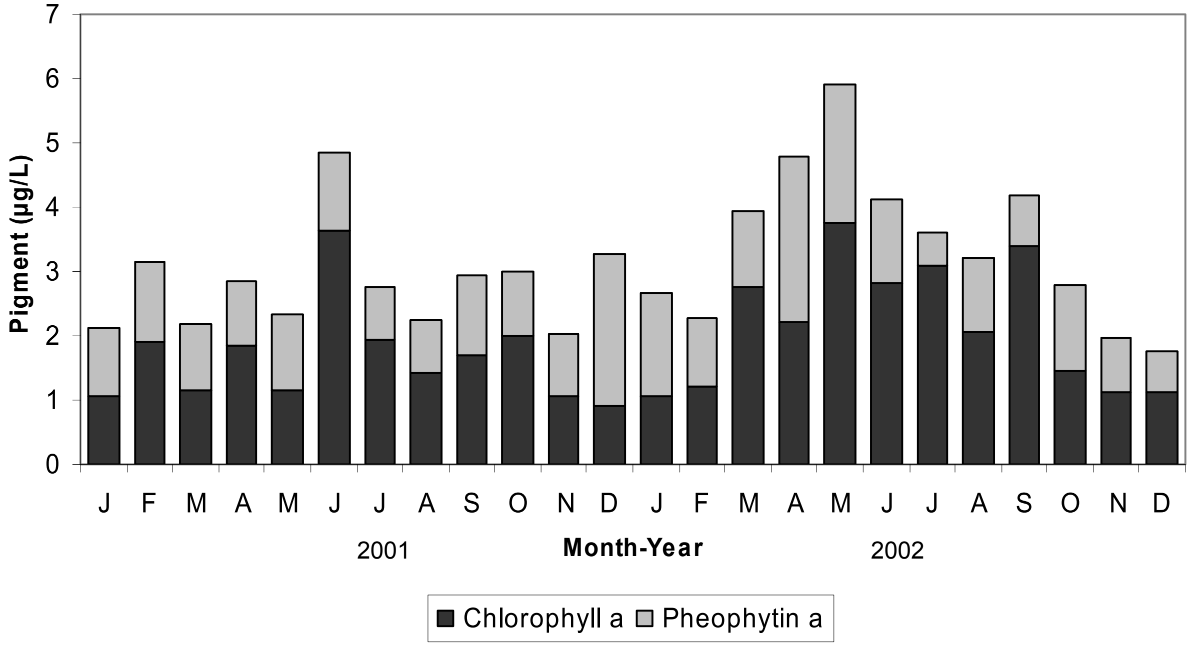

Figure 4-11 Chlorophyll *a* and pheophytin *a* concentrations at station D7, 2001-2002

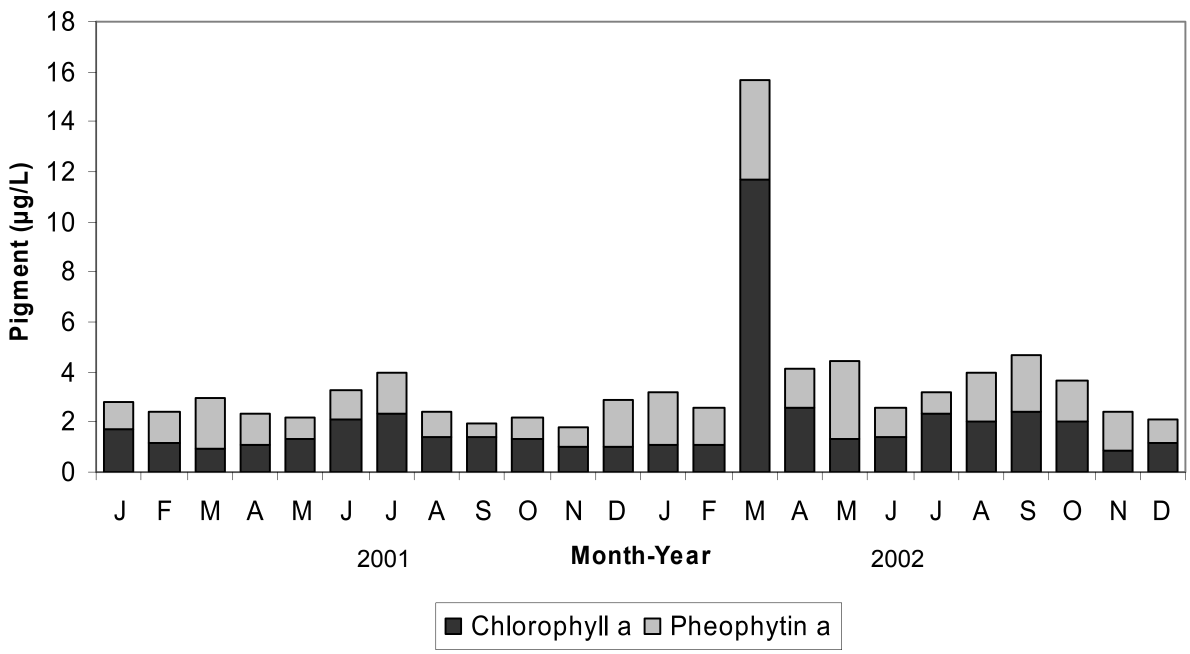

Figure 4-12 Chlorophyll *a* and pheophytin *a* concentrations at station D6, 2001-2002

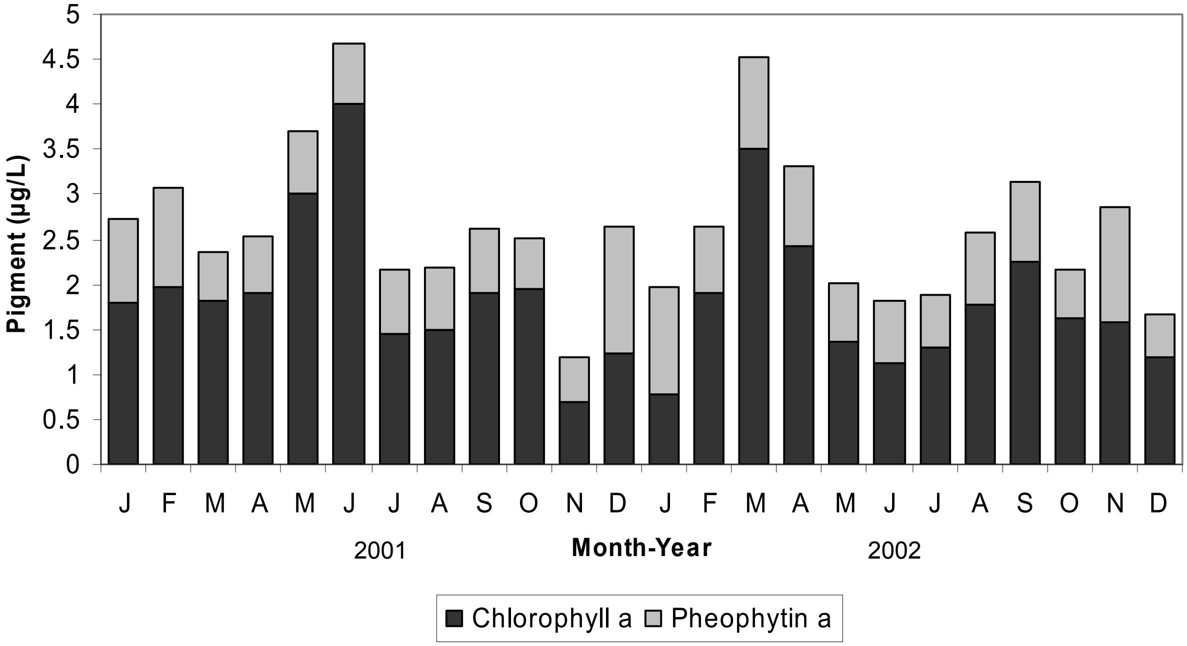

Figure 4-13 Chlorophyll *a* and pheophytin *a* concentrations at station D41, 2001-2002

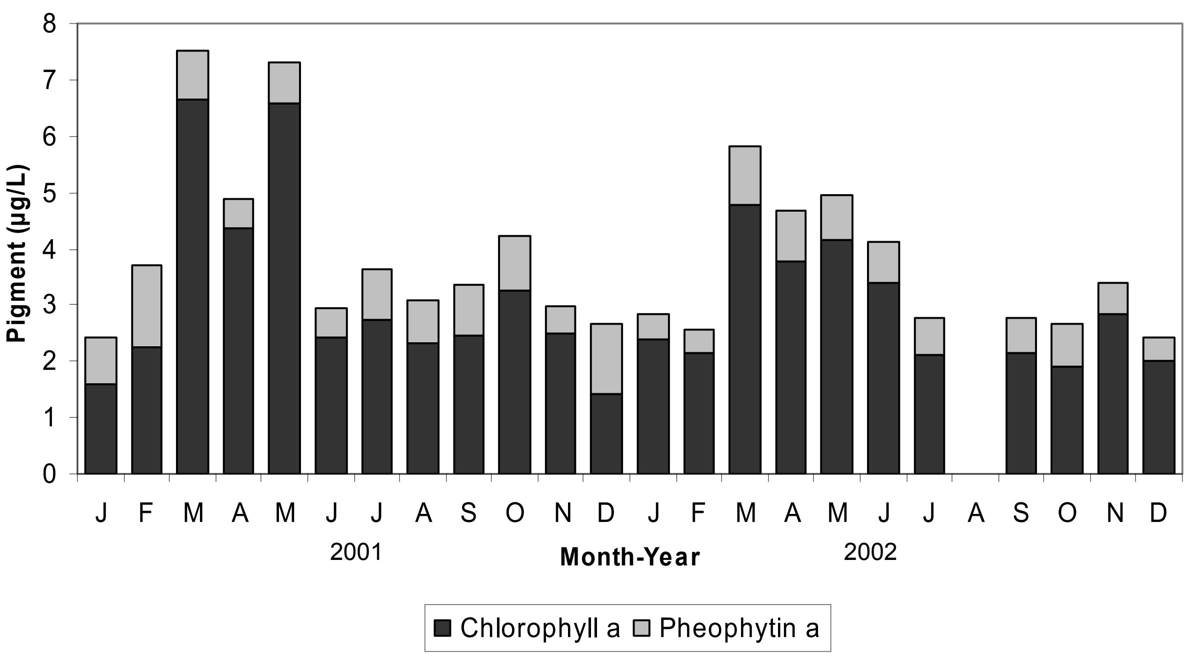

Table 4-1 All genera found in each family in the upper San Francisco Estuary

Family	Genus	Family	Genus
Bacillariophyceae	*Achnanthes*	Chlorophyceae	*Actinastrum*
	Amphiprora		*Ankistrodesmus*
	Amphora		*Carteria*
	Asterionella		*Chlamydomonas*
	Bacillaria		*Chlorella*
	Ceratoneis		*Closteriopsis*
	Cocconeis		*Closterium*
	Cosinodiscus		*Coelastrum*
	Cyclotella		*Crucigenia*
	Cymbella		*Desmidium*
	Diatoma		*Dictyosphaerium*
	Fragilaria		*Dimorphococcus*
	Gomphonema		*Elakatothrix*
	Gyrosigma		*Eudorina*
	Melosira		*Micractinium*
	Navicula		*Oocystis*
	Neidium		*Pandorina*
			Pediastrum
Chrysophyceae	*Synura*		*Pyramimonas*
			Scenedesmus
Cryptophyceae	*Cryptomonas*		*Schroederia*
	Rhodomonas		*Selenastrum*
			Sphaerocystis
Cyanophyceae	*Agmenellum*		*Staurastrum*
	Anabaena		*Tetraedron*
	Anabaenopsis		*Tetrastrum*
	Anacystis		*Ulothrix*
	Aphanizomenon		*Xanthidium*
	Gomphosphaeria		
	Oscillatoria		
	Spirulina		
Dinophyceae	*Ceratium*		
	Glenodinium		
	Gymnodinium		
	Peridinium		
Euglenophyceae	*Euglena*		
	Trachelomonas		
Unidentified	Unidentified Flagellates		